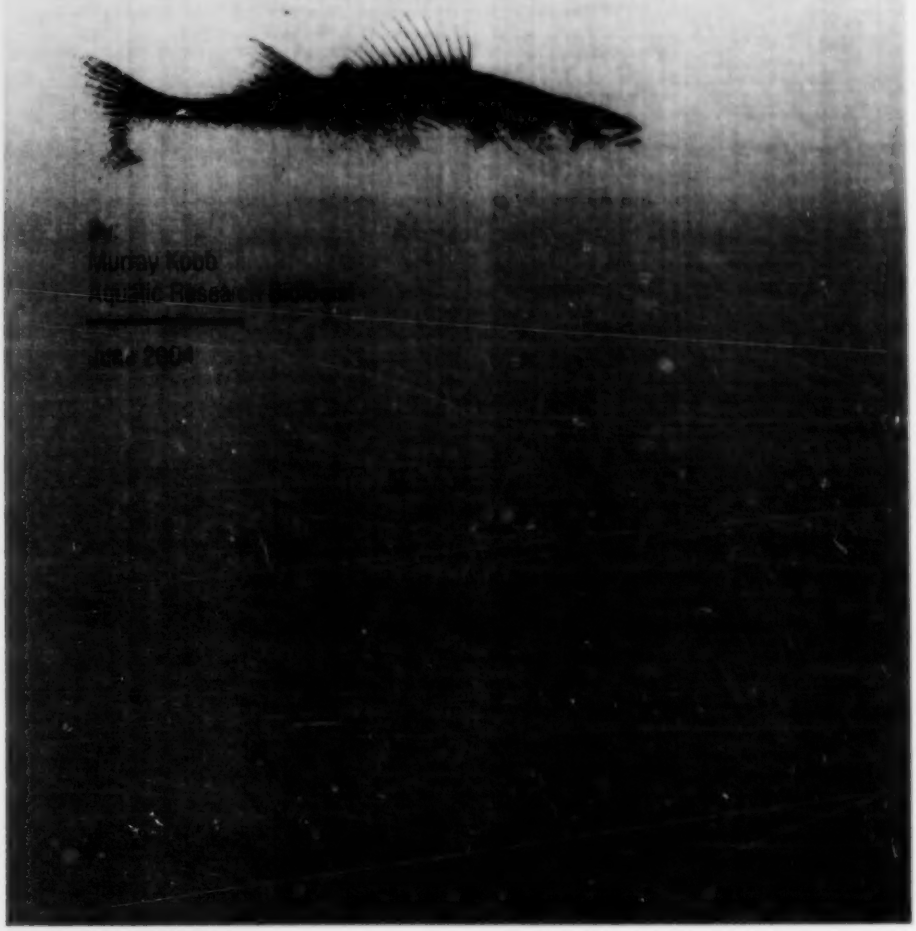
Saskatchewan
Environment

Seasonal Movement, Habitat Use and Spawning Activity of Walleye (Sander vitreus) in Candle Lake, Saskatchewan as Determined by Ultrasonic Telemetry

Resource Technical Report 2004-2



Murray Koob
Aquatic Research Biologist

June 2004

Recycled Paper

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By:
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Job Completion Report
May 2003

by

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Saskatchewan Environment

Resource Stewardship Branch
Prince Albert, Saskatchewan
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ABSTRACT

The seasonal movements, habitat use and spawning activities of twenty adult walleye were monitored in Candle Lake, Saskatchewan from September 1998 to November 2001 using ultrasonic telemetry. Most walleye (75%) confined the majority of their activities to specific areas of Candle Lake. Activity areas were greatest during the spring ($\bar{x}$ = 948 ha) and lowest during the winter ($\bar{x}$ = 94 ha). Walleye mean depth progressed seasonally, ranging from 3.4 m (winter) to 6.4 m (fall) and most telemetered walleye locations favored firm substrates (sand, rock or gravel). During years of favorable spring water flows in Fisher Creek, significant numbers of Candle Lake walleye were observed migrating into Torch Lake, where they successfully spawned. Although, Torch Lake is generally devoid of typical spawning habitat, evidence suggests that walleye have likely adapted to utilizing non-typical habitats for spawning purposes.

ACKNOWLEDGMENTS

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INTRODUCTION

The walleye *(Sander vitreus)* is native to Saskatchewan and is one of the most sought after recreational fish species in the province. General provincial management practices for walleye include the use of spring spawning closures and a creel limit of 5 fish, one of which may exceed 55 cm. Supplemental fry stocking sustains viable populations in many of the small to medium-sized lakes in the southern half of the province, with northern waters and the larger lakes of the south reliant on natural recruitment.

An ever increasing recreational demand for walleye throughout the province, particularly on the less productive lakes of the central management zone, has forced fisheries managers to adopt more restrictive individual lake management practices in recent years. Candle Lake is typical of this situation. In 1998, a proposed 60% reduction in the walleye creel limit for Candle Lake was introduced by Saskatchewan Environment in an effort to protect the lake from a perceived over harvest of walleye. Local opposition successfully refuted the proposal on the premise that existing data was insufficient to support the creel reduction. In response, a local fish advisory committee was formed to provide Saskatchewan Environment with advice on future fisheries management issues concerning Candle Lake.

A greater knowledge of walleye behavior and habitat use on Candle Lake will assist managers in establishing improved walleye management practices for the lake. The objectives of this study were to: (1) identify walleye spawning sites and associated substrates, (2) determine seasonal habitat use and depth selection of walleye, and; (3) determine the seasonal distribution and movement of walleye within Candle Lake.

STUDY AREA

Candle Lake is a large oligotrophic lake in central Saskatchewan and is located approximately 60 km north east of the city of Prince Albert. It has a surface area of 13,183 ha, a maximum depth of 17 m and 70 km of shoreline. Candle Lake's total watershed covers an area of 167,276 ha, 87% of which is forested. Silt, mud and clay are the dominant substrates in depths greater than 5 m (72% total area). Coarser materials such as sand and rock are more common in the shallow areas, comprising 90% of the littoral zone (9% total area) and 57% of the 2 - 5 m depth zone (19% total area)(Liaw 1999). The main tributaries of Candle Lake are the Whitefish River, Hanin Creek, Clearsand Creek (originating from Clearsand Lake) and Fisher Creek (originating from Torch Lake)(Appendix 1). A spring closure on Fisher Creek and a part of Candle Lake near the creek mouth was enacted in 1976 to protect concentrations of spawning walleye from angler over harvest.

Torch Lake is situated approximately 1 km south west of Candle Lake and is historically perceived to be the main spawning and rearing area for walleye from Candle Lake. It has a surface area of 1,143 ha and a maximum depth of 2 m. A water control structure on the Torch River, Candle Lake's primary outlet, maintains water levels within the lake for recreational and fish spawning purposes. Recreational development on Candle Lake includes a Provincial Park with 244 campsites, 1500 cottages with 600 permanent residents and 4 resorts with accommodation for 212 persons. Sixteen fish species inhabit Candle Lake, with walleye being the most abundant major species.

METHODS AND MATERIALS

Transmitter Implantation

Fish and Wildlife Branch staff implanted ultrasonic transmitters into adult walleye from Candle Lake and tracked them from September 1998 to November 2001. Transmitter implantation was carried out during the fall to avoid disruption of spring spawning activity. Fish were collected from two separate locations on the lake using trap netting and angling. Captured walleye were transported to lakeshore implantation sites in an aerated holding tank, where they remained until surgery.

Prior to surgery, walleye were anesthetized in a 50 mg/L solution of tricane methane sulfonate (MS-222). Induction time averaged 2 to 3 minutes per fish. The walleye were then placed ventral side up in a V-shaped foam block. During the surgical procedure, a constant flow of fresh water, periodically supplemented with MS-222 solution, was maintained over the fish's gills. Surgical gloves were worn at all times during the procedure and all surgical tools were disinfected before use. Before incising each fish, a topical disinfectant (Betadine®) was used to clean the incision area. A 3 cm long incision was made approximately 5 to 7 cm anterior and slightly lateral to the midline of the vent. The transmitter was then inserted into the body cavity and the incision was closed with a 3-0 Ethicon nonabsorbable suture. To help protect against infection, 0.2 mL of Bio-mycin® was injected into the musculature adjacent to the incision. Vetbond® was applied to the incision to secure suture knots and prevent water from entering into the body cavity. The surgical procedure typically lasted 10 - 15 minutes. Following surgery, the fish were held for observation in an aerated holding tank to verify postoperative recovery. A numbered, orange Floy tag stating "Fisheries Research Project - Please Release", was inserted just behind the dorsal fin as an external marker for anglers. All efforts were made to release the tagged fish near their original capture sites.

Telemetry Monitoring

The telemetry equipment used in this study was obtained from Sonotronics of Tucson, Arizona and consisted of a USR-96 narrow band receiver, a DH-2 directional hydrophone and twenty CT-82-2 transmitters. Ultrasonic telemetry was chosen over radio telemetry because of its ability to provide a greater positional accuracy (≤3m) and depth range (≥5m). The transmitters were cylindrical in shape, measuring 64mm (length) x 16mm (diameter) and weighing 8 grams in water. Winter (1978) recommended that a transmitter's weight in water should not exceed 1.25% of the fish's weight out of water. Therefore, walleye ranging from 680 to 1290 grams in weight were selected for this study (Table 1).

Table 1. Tagging data from walleye implanted with transmitters in Candle Lake

Fish number	Date implanted	Transmitter frequency	Transmitter Pulse	Floy Tag	Length (cm)	Weight (g)	Duration (days)
1	30/09/98	71K	2-8-5	11	49.0	1290	300
2	30/09/98	71K	2-7-6	18	43.0	850	379
3	30/09/98	71K	2-9-4	13	44.0	900	379
4	30/09/98	73K	4-5-6	10	43.5	980	379
5	30/09/98	74K	3-8-4	17	39.0	680	300
6	01/10/98	72K	3-3-9	24	41.5	795	187*
7	01/10/98	73K	3-6-6	16	44.0	910	271
8	01/10/98	73K	4-4-7	22	41.5	810	299
9	08/10/98	74K	4-6-5	25	43.5	870	264*
10	27/10/98	74K	3-7-5	26	41.5	800	352
11	08/09/00	72K	3-5-7	90	45.0	975	290*
12	08/09/00	72K	3-2-9	91	46.0	1150	396
13	08/09/00	72K	3-4-8	93	43.0	825	290
14	08/09/00	74K	4-5-8	96	41.0	750	430
15	08/09/00	75K	2-6-7	98	42.0	800	352
16	08/09/00	75K	2-5-8	92	42.0	800	430
17	08/09/00	75K	2-4-6	87	52.0	1000	196*
18	08/09/00	75K	5-6-6	96	44.5	900	405
19	08/09/00	75K	5-5-7	89	49.0	1225	53
20	08/09/00	76K	5-6-9	87	46.0	1000	430

died of unknown causes

The life expectancy of each tag was 12 to 14 months. Transmitters operated on frequencies ranging from 71 to 76 kHz, and were uniquely coded by differences in the pulse rate of each emitted signal, thereby allowing for individual fish identification.

Conditions permitting, tracking was usually attempted once per week throughout most of the study, except during the spring, when the frequency of the tracking events increased to monitor spawning activity. Tagged walleye were located through a series of subsurface observations with the hydrophone while traveling the perimeter of the lake by boat (open water) or snowmobile (ice cover). Once a transmitter signal was detected, the location of the fish was determined to within ±3 m by following the directional signal until it became omnidirectional. Ultrasonic signals can be seriously affected by macrophytes, algae, thermoclines, turbulence and underwater structure (Winter 1978). The range of transmitter signals detected in this study varied from 500 - 5,000 m on Candle Lake ($\bar{x}$ = 1,500 m) and from 100 - 1,500 m on Torch Lake ($\bar{x}$ = 500 m).

Data recorded with each fish location included Universal Transverse Mercator (UTM) coordinates, water depth, time and date. The CT-82-2 transmitters were not depth sensitive and walleye depths had to be estimated utilizing an Eagle® LCR sonar with the assumption that the fish were generally located near the bottom. Coordinates were captured with a Garmin 12XL® Global Positioning System (GPS) receiver and later analyzed with a Geographic Information System (GIS) using ArcView® software. Activity areas were calculated with the Animal Movement Analyst Extension to ArcView® using the minimum convex polygon method. Substrate information collected by Liaw (1996) for Candle Lake was applied during the GIS analysis.

Telemetry data was analyzed by season and categorized as Winter (December - March), Spring (April - June), Summer (July - August) or Fall (September - November). Spawning activity evaluation efforts were concentrated primarily on Torch Lake in 1999 and included an inventory of the walleye spawning run on Fisher Creek; air lift egg sampling of suspected spawning sites on Torch Lake, and; an assessment of the walleye young of the year emigration from Torch Lake.

RESULTS AND DISCUSSION

Telemetry Tracking Success

Twenty adult walleye were implanted with ultrasonic transmitters, ten of which were tagged during the first phase of the study (September 1998 - October 1999). The remaining ten specimens were tagged during the study's second phase (September 2000 - November 2001). No determinations of sex were made on either occasion. Four walleye were tracked for 400+ days, eight walleye for 300+ days, five walleye for 200+ days and three walleye for less than 200 days. Sixteen of the twenty walleye tagged (80%) provided the majority of data during the study, accounting for 90% (457 of 508) of the total observations. Limited tracking was realized from four walleye due to post operative mortality (#339 and #246) and transmitter failure (#557 and #447).

Most telemetered walleye tended to inhabit specific areas within Candle Lake. Ten of sixteen walleye (63%) spent 78% of their time within 3 km of their original capture site. Two walleye established and maintained limited activity areas away from their original capture site, in which they spent 72% of their time. Four walleye were more nomadic and were widely distributed throughout the lake. The circumscription of walleye activity to specific areas (home range, activity area) has been documented in several bio-telemetry studies. Ager (1976) found that monitored walleye in Central Hills Reservoir, Tennessee, displayed two distinct behavioral patterns, with some fish wandering throughout the reservoir never utilizing any particular area repeatedly, while others remained within a limited area. Williams (1997) reported that 67% of telemetered walleye in Laurel Lake Reservoir, Kentucky established a single activity area by early June, with most areas (75%) $\leq$ 300 ha in size. Parks and Kraai (1991) stated that walleye in Meredith Reservoir, Texas, established home ranges, with 79% of the study fish occupying areas of $\leq$ 1,200 ha. Pitlo (1978) determined that West Lake Okoboji, Iowa walleye established activity centers from mid-June through mid-October.

Three tagged walleye were caught by anglers during the study. Walleye #276 was caught and released at its original release site on June 19, 1999. Walleye #294 was caught and kept on August 19, 2000, 2.5 km from its release site and walleye #285 was caught and kept on June 16, 2001, 2.0 km from its release site. Transmitter batteries for #294 and #285 had expired and external floy tags requesting the fish's release were absent. A fourth walleye (#258) was caught and kept on March 30, 2003, approximately 2.5 km from the confluence of Fisher Creek and 7 km from its original release site.

Seasonal Movement and Habitat Use

Spring

Activity areas were greatest in the spring, primarily due to spawning movements, with walleye ranging from 112 - 2574 ha ($\bar{x}$ = 948 ha). Similar patterns in spring walleye activity have been observed in Leech Lake, Minnesota (Schupp 1972), Lake Bemidji, Minnesota (Holt et al 1977) and Laurel Lake Reservoir, Kentucky (Williams 1997).

Migrations to suspected spring spawning sites occurred under the ice in Candle Lake from April 12th - 18th during both phases of the study, with ten of sixteen walleye (63%) traveling an average of 11.1 km from winter activity areas to a pre-spawn staging area (range 9.5 - 14.5 km). Ager (1976) reported spawning movement rates of 3.2 to 16.1 km per day in Central Hills Reservoir, Tennessee. During the spring, walleye in Candle Lake were located primarily over firm, coarse substrates, with 70% of telemetry fixes related to sand, rock or gravel (Figure 1). Substrate use in Torch Lake was limited to soft, fine substrates (silt and mud), which account for 99% of the lake's total area. Walleye utilization of off-shore structure (reefs and shoals) within Candle Lake during this period was 12%. By mid June, most walleye had abandoned their spawning grounds and returned to their home range areas. Spring tracking produced a total of 171 observations from 16 walleye. Tracking was discontinued for approximately 3 weeks during spring breakup in 1999 and again in 2001 due to unsafe ice conditions for travel.

Summer

Fish movements began to decrease with the summer period and the warming of water temperatures. Walleye summer activity areas ranged from 37 - 457 ha, with a mean of 228 ha. Limited walleye movement during the summer was also noted by Schupp (1972), Holt et al (1977) and Williams (1997). Hall (1982) found that walleye in Jamestown Reservoir, North Dakota, established average summer activity areas of 45.4 ha and Pitlo (1978) determined that summertime activity of walleye in West Lake Okoboji, Iowa, ranged from 7 - 77 ha. Candle Lake walleye were associated with sand and rock substrates 54% of the time throughout the summer (Figure 1). The use of off-shore structure peaked during this period at 25 %. Transmitter expiration and numerous equipment problems led to a low number of observations from the summer (46 of 508), with only seven walleye providing data.

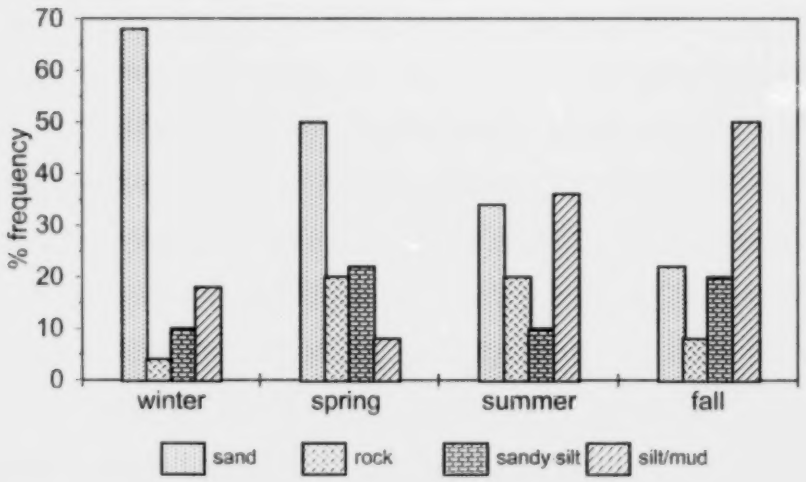

Figure 1. Seasonal substrate use by walleye in Candle Lake, Saskatchewan

Fall

Similar to the findings of Schupp (1972), Ager (1976), Holt et al (1977) and Williams (1997), walleye movement began to increase with the decline of water temperatures in the fall. Fall activity areas ranged from 22 ha - 2,878 ha, with a mean of 662 ha. Diel walleye activity, which was only monitored in the fall during the first phase of the study, averaged 1,613 m per day (range 244 - 6,200 m) and is consistent with William's (1997) findings of 1,450 m from Laurel Lake Reservoir, Kentucky. Walleye displayed a preference for softer substrates, with 70% of telemetry fixes favoring silt, mud or clay (Figure 1). Use of off shore structure within Candle Lake during the fall did not vary significantly from the summer, averaging 23%. The fall period produced a total of 146 observations from 20 walleye through both phases of the study. No data was collected for approximately seven weeks during the fall-to-winter transition due to unsafe ice conditions for travel.

Winter

Walleye movement was very restricted throughout the winter, with activity areas ranging from 5 - 894 ha ($\bar{x}$ = 94 ha). Thirteen of ninteen walleye (68%) were sedentary, confining activities to an average area of 14 ha (range 5 - 20 ha). These findings are in contrast with the results presented by Ager (1976) and Williams (1997), both of whom reported high winter movement rates in walleye. The restricted walleye activity documented in Candle lake during the winter may be a result of the prolonged reduction in light conditions under the ice brought about by a shortened photoperiod and peak snow and ice cover. Similarly, Gross et al (1965) observed minimal activity and growth in laboratory sunfish subjected to a low photoperiod preceded by a decrease in day length conditions. The sedentary nature of the telemetered walleye may also help to explain the relatively poor angler returns associated with this period. Only one walleye (#384) remained relatively active, with movements encompassing an area of 894 ha. Sand and rock substrates were associated with 72% of all observations from the winter (Figure 1) and use of off shore structure reached its lowest point of the study at 9%.

A total of 145 contacts were made from 19 walleye throughout this period. From late November to early May during both phases of the study, the entire surface of Candle Lake was covered in a layer of ice and snow, with respective amounts totaling 90 and 40 cm by mid February, and diminishing to 60 and 0 cm by early April.

Use of shoreline habitats was greatest during the winter and spring. Walleye gradually moved deeper as the seasons progressed and began to occupy main lake habitats with the onset of summer. Tagged walleye mean depth for Candle Lake was 3.4 m (winter), 3.8 m (spring), 5.6 m (summer) and 6.4 m (fall) (Figure 2) and is consistent with the findings of Pitlo (1978) and Parks and Kraai (1991), who both reported that most walleye were found in depths of ≤ 8 m. Einhouse (1981) also reported a depth range of 2 - 7 m for tagged walleye in Chautauqua Lake, New York, and Rawson (1956) stated that walleye were found to inhabit the shallower bay areas of Lac la Ronge, Saskatchewan during the winter period. Some literature suggests that walleye tend tomove deeper during the summer to avoid water temperatures ≥ 21° C. Rawson (1956) indicated that the movement of adult walleye into deeper water during the mid-

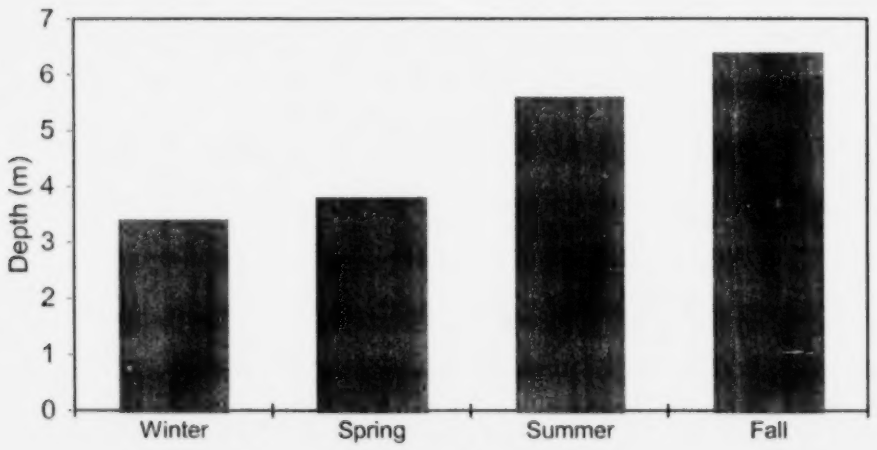

Figure 2. Walleye seasonal mean depth in Candle Lake, Saskatchewan

summer to fall seasons in Lac la Ronge was likely due to the pursuit of forage and not the avoidance of high water temperatures, as surface temperatures in Lac la Ronge rarely exceed 19°C.

Eschmeyer (1950) also found that Michigan Lake walleye were generally located at the depth of their forage. With summer surface water temperatures in Candle Lake ≤ 21°C, walleye movement to deeper water in Candle Lake is presumably a result of forage location. Dissolved oxygen was not a limiting factor to seasonal walleye depth selection at anytime during this study with concentrations ranging from 5.4 ppm at 16 m (August) to 12.7 ppm at the surface (January).

Spawning Evaluation - 1999

Five of nine tagged walleye (56%) migrated into Torch Lake via Fisher Creek in April to spawn. Each fish staged near the confluence of Fisher Creek for approximately one week prior to leaving Candle Lake. Three walleye (#366,#294 & #285) entered the creek under the ice on April 20th. The remaining 2 walleye (#456 & #465) were captured in Fisher Creek on April 24th during a trap net inventory of the walleye spawning run. The inventory was conducted from April 22nd to May 5th and enumerated a total of 10,492 walleye; 51 % were female (mean FL = 45.5 cm) and 49 % were male (mean FL = 41.3 cm). The velocity of Fisher Creek during this period averaged 0.16 m/sec. Less intensive spawning investigations on Hanin and Clearsand Creeks during the same period did not capture any walleye. Walleye typically spawn in streams or along lake shores over rocks, gravel or sand (Priegel 1970). Such preferred spawning habitats are generally absent in both Torch Lake and Fisher Creek, with softer substrates (silt and mud) comprising 99% of the total area. The small amount of firm, coarse substrates only occur in selected areas along Torch Lake's foreshore and give way to softer substrates at approximately 30 cm of depth.

Walleye spawning in lakes begins shortly after ice break-up at water temperatures of 6.7°C to 8.9°C, but has been known to occur over a range of 5.6°C to 11.1°C. Eggs hatch in 12 - 18 days in temperatures prevalent on the spawning grounds (Scott and Crossman 1973). Ice break-up on Torch Lake occurred April 25th and on Candle Lake May 5th. Temperature data from Torch Lake indicates that peak walleye spawning likely occurred from May 1st - 10th, with fry emergence beginning around May 20th (Appendix 2).

One walleye (#285) was typically associated with what was perceived to be suitable spawning substrate in Torch Lake. The site was located midway along the eastern shore and consisted primarily of sand with some scattered rock. Johnson (1961) suggests that egg survival is only intermediate on firm, clean sand, while Priegel (1970) reported that eggs deposited on sand bars were washed away by water currents onto detritus and silt substrates where heavy egg mortality occurred. A thorough inspection of the suspected Torch Lake spawning site with an air lift egg vacuum failed to confirm walleye egg deposition. The remaining four walleye (#366, #294, #456 and #465) were randomly distributed throughout much of the northern and southern portions of Torch Lake during the spring. Typical spawning substrates are generally absent from these areas of the lake and submerged vegetation cover is extensive, with *Chara* spp. and pondweed the dominant types.

Several studies have documented walleye use of non-typical habitat for spawning purposes. Wendlandt (1996) documented walleye egg deposition over sandy areas with a dominant vegetative cover of *Chara* spp. in Lake Minnewaska, Minnesota. Dombech (1984) noted that *Chara* spp. provides support for eggs of bottom spawning species and protects them from predation. Priegel (1970) reported that in the spawning marshes of Lake Winnebago, Wisconsin, walleye successfully use grasses and sedges as mats on which to loosely broadcast their eggs. The mats prevented the eggs from coming in contact with the soft muck and detritus substrate, where high egg mortality was experienced. The lack of preferred spawning substrates in Torch Lake and the evidence

to suggest that walleye do not use them would indicate that it is very likely that walleye utilize non-typical habitats on which to deposit their eggs. However, no effort was made to document the use of these non-typical habitats by spawning walleye.

Young of the year trap netting was periodically conducted on Fisher Creek from June 22nd to October 20th to verify reproductive success and to monitor the return of walleye fingerling into Candle Lake. Frequent rainfall throughout most of the spring and early summer periods maintained Torch Lake outflows (Fisher Creek) at approximately 0.05 m/sec. Fingerling were observed in the creek during the first assessment on June 22nd, but were too small (≤ 4 cm) to capture with the sampling gear. Priegel (1970) reported that newly hatched walleye fry moved out of Spoehr's Marsh, Lake Winnebago, Wisconsin when water currents were sufficient enough to carry the fry out of the marsh. Given the sustained outflows from Torch Lake during the spring of 1999, it is probable that walleye emigration began at the fry stage. Emigration continued throughout July with rates averaging approximately 300 (5 - 6 cm) fingerling per 24 hour period. By August, fingerling numbers had decreased to approximately 100 per day (7 cm). Fingerling sampling on Fisher Creek and Torch Lake in October produced no young of the year walleye.

The return of telemetered walleye from Torch Lake began with #285 on May 20th. Three walleye (#366, #294 & #456) emigrated between June 13th and 19th and one fish (#465) died shortly after spawning of unknown causes. Of the four tagged walleye remaining in Candle Lake during the spring (#276, #375, #384 & #447), none exhibited any signs of spawning behavior. Temperature data for Torch Lake was recorded from April 21 to September 9, 1999 with a TidBit® Templogger and is reported in Appendix 22. A TidBit® Templogger was unsuccessfully deployed in Candle Lake during the same period.

Spawning Evaluation - 2001

Between April 12th and 18th, 2001, three of eight tagged walleye (38%) traveled under the ice to stage at the confluence of Fisher Creek. Below normal water levels in Torch Lake and a less than average spring run-off caused Candle Lake to outflow into Torch Lake, creating a reverse flow of 0.01 m/sec to occur in Fisher Creek. Between April 24th to 26th, walleye #258 and #357 entered Fisher Creek, while walleye #329 reverted to its home range area along the north west shore of Candle Lake. A trap net assessment of walleye spawning frequency in Torch Lake from May 14th - 16th captured three walleye. In comparison, a similar study conducted in 1997 yielded 63 walleye, indicating a significant reduction in walleye spawning activity in Torch Lake during 2001, which can likely be attributed to the inability of Fisher Creek to attract spawning walleye due to insufficient spring flows. No additional spawning evaluations were conducted on either Torch Lake or Fisher Creek during the study's second phase.

Of the six walleye remaining in Candle Lake, #329, #348, #458, #566 and #569 were exclusively associated with the littoral area of the north west corner of the lake from May 13th - June 14th. Substrates in this area are predominantly sand and rock. Observed water temperatures were approximately 4 - 5°C warmer than main lake temperatures, indicating possible walleye spawning activity. However, no attempt was made to confirm walleye egg deposition. Poor rearing conditions in Candle Lake due to cool water temperatures and a low standing plankton crop of 38.1 kg/ha (Johnson 1963) would suggest that fry survival would likely be minimal, underlining the significance of Torch Lake as a walleye spawning and rearing area for Candle Lake.

MANAGEMENT RECOMMENDATIONS

Telemetry provides a means to monitor the biology of animals not readily visible, gathers data with a minimal influence on the animals behavior and health and collects more data than are normally obtained by techniques such as mark and recapture (Winter 1978). Several studies on the movements of walleye have previously been conducted in Saskatchewan, however this study denotes the inaugural use of ultrasonic telemetry for fish monitoring purposes in this province.

This study was able to identify Torch Lake as an important spawning and rearing area for Candle Lake walleye, albeit further evaluation is required to qualify the use of non-typical spawning habitats within Torch Lake. Walleye recruitment in Torch Lake is currently able to sustain Candle Lake walleye populations at the present angler harvest rate of 0.8 kg/ha (Wallin 2000), although the amount of available suitable spawning habitat in Torch Lake appears to be limiting potential production. Spawning substrate enhancement would improve recruitment and should be considered if an increase in walleye production is desired. However, the success of substrate enhancement may only be short term, due to the potential degradation of the substrates by silt. Therefore, it is recommended that any rock placement be initiated on a small scale and evaluated thoroughly before proceeding with a comprehensive development.

Telemetry tracking indicates that post-spawn walleye remain in Torch Lake until mid June before returning to Candle Lake. An extension of the Fisher creek spawning closure to June 15th from mid-May and the inclusion of Torch Lake in the closure would afford walleye better protection throughout the entire spawning period. Results from this study also suggest that the closure on the portion of Candle Lake adjacent to the mouth of Fisher Creek may not be as effective in protecting concentrations of spawning walleye as the 1985 advancement of the angling season closure from April 15th to March 31st, with most walleye staging near the Fisher Creek confluence from April 12th - 18th, approximately two weeks after the completion of the angling season.

Ultrasonic telemetry technology was successfully utilized to assess the behavioral characteristics of walleye in Candle Lake. Based on the experiences gained from this study, consideration should be given to the following if contemplating the use of ultrasonic telemetry for fish tracking:

- Ultrasonic tracking demands a significant time commitment, requiring considerable dedication of personnel for adequate data collection. Similar results may be achievable through simpler techniques.
- Ultrasonic signals in Torch Lake were noticeably reduced and often undetectable in the shallow, heavily vegetated areas of the lake, indicating that this technology is not well suited for the tracking of individual fish movements in these environments.
- Optimal coverage with ultrasonic tracking is best accomplished on small to mid-sized waterbodies with a low shoreline development index. When compared to 15 other telemetered waterbodies (range 31 - 8,500 ha), Candle Lake is quite large in size (13,183 ha) and should be viewed as being in the upper range of feasibly acceptable study lakes. Larger lakes are also prone to increased wave action which reduces signal reception due to interference. A low shoreline development index (Candle Lake 1.8) helped to minimize the occurrence of signal blockage, thereby increasing range.
- Hypolimnetic signal transmission was significantly degraded by the presence of a thermocline, suggesting that ultrasonic telemetry would not be practical for the monitoring of deep dwelling fish in waterbodies subject to stratification.
- Total Dissolved Solids (TDS) had a negative effect on signal transmission. This was illustrated during a pre-study evaluation of the ultrasonic telemetry system on nearby Christopher Lake, Saskatchewan (TDS = 1200 ppm), where the signal range was noticeably less than that experienced at Candle Lake (TDS = 235 ppm).

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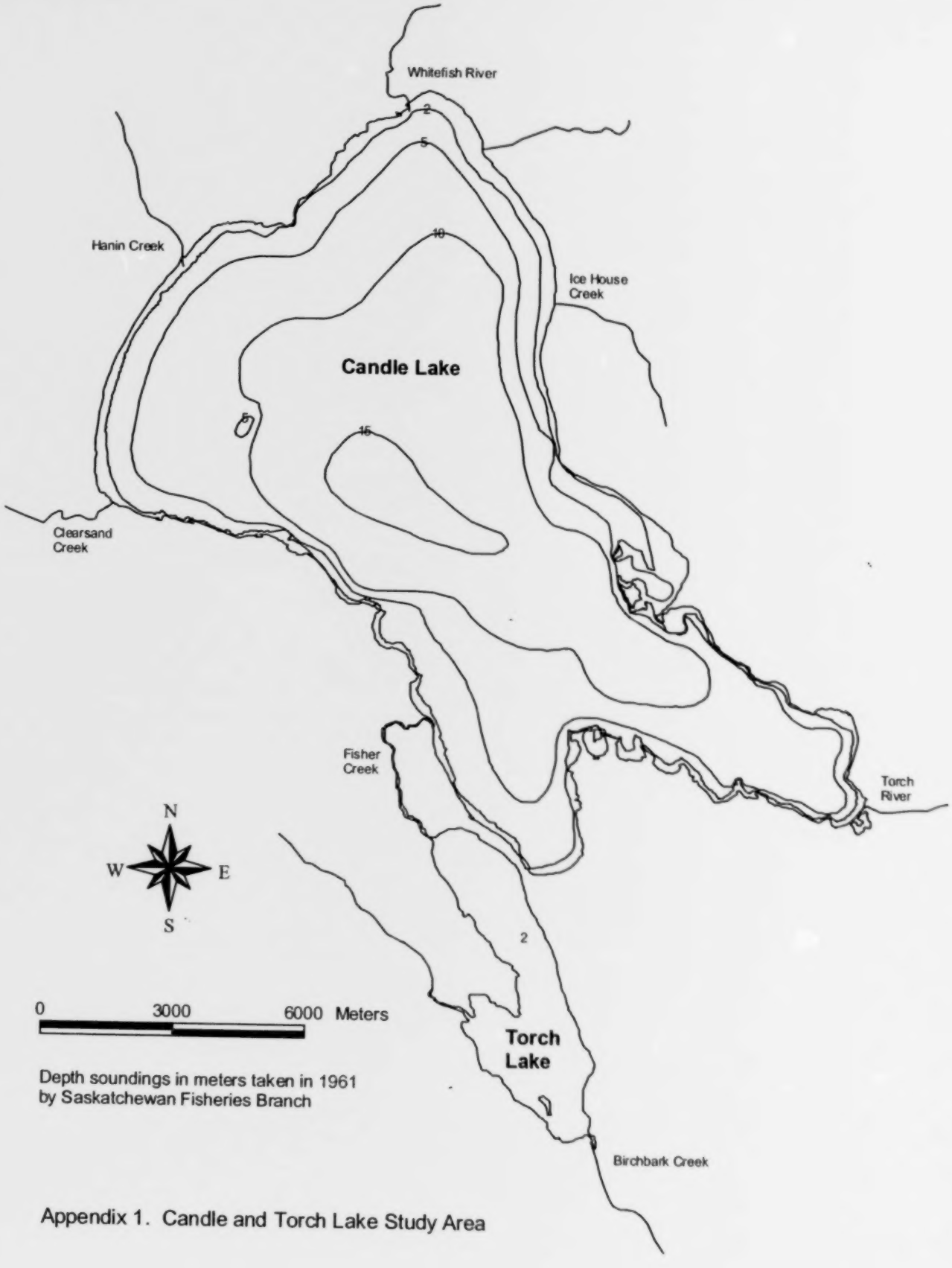
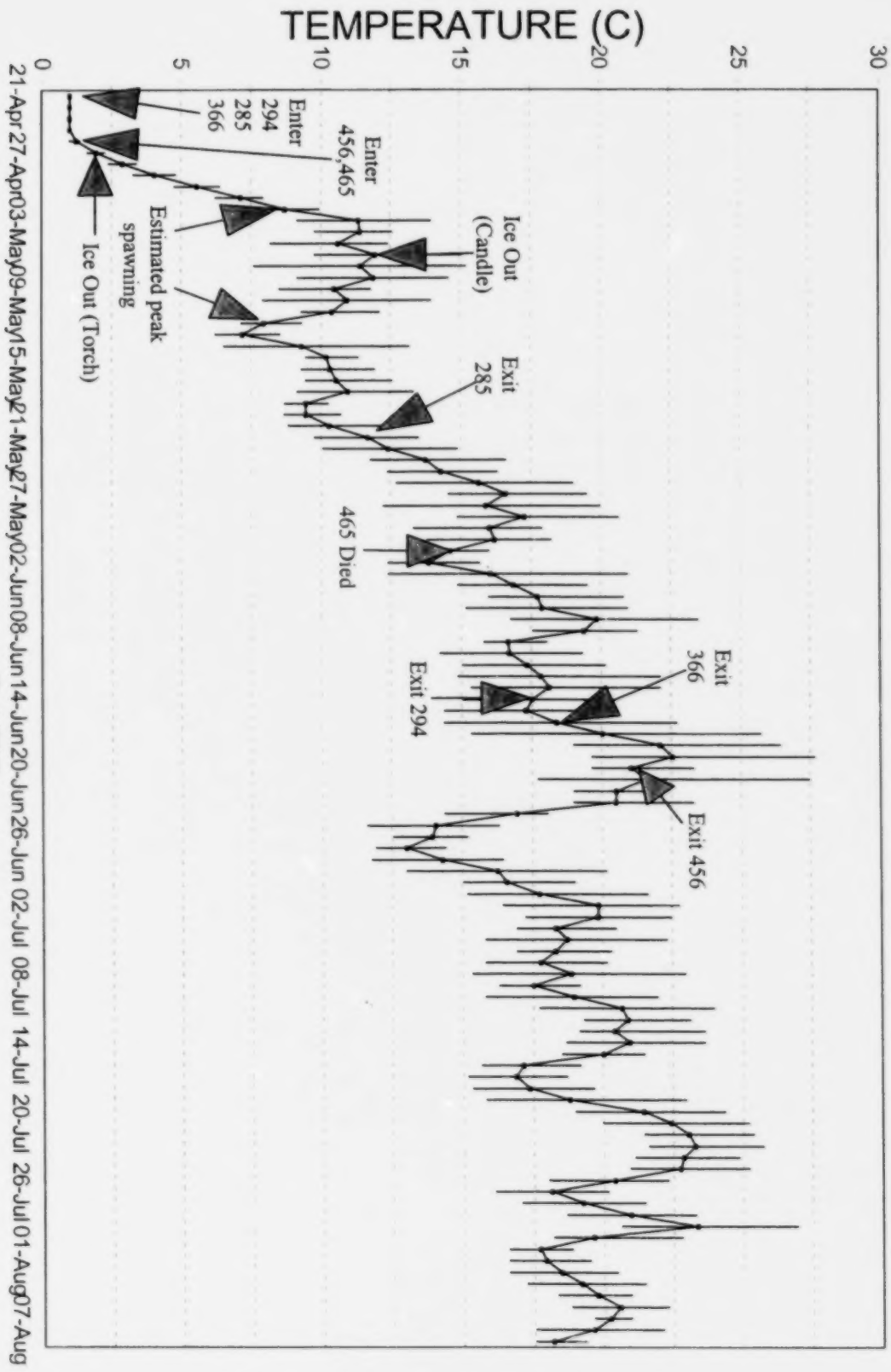


Depth soundings in meters taken in 1961 by Saskatchewan Fisheries Branch

Appendix 1. Candle and Torch Lake Study Area



Appendix 2. Torch Lake Hi/Lo Temperatures (1999)